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CHAPTER 1: INTRODUCTION

Hydrology, geomorphology and habitat studies of the San Juan River began in 1992 as a part of the San Juan River Basin Recovery Implementation Program (SJRIP). The work reported here represents activities completed through 1998 as part of the seven-year research effort incorporated into the SJRIP.

The purpose of the SJRIP is to "protect and recover endangered fishes in the San Juan River basin while water development proceeds in compliance with all applicable federal and state laws" (SJRIP Program Document, February 1995). Objective 4.2 of the long range plan developed as part of this program document is to identify, protect and restore habitats, recognizing that recovery of endangered species is linked to the condition of their habitat. As a part of this objective a need for modeling the response of habitat to flow was identified. Further, the response of channel morphology to research flows is necessary to define the relationship between flow and habitat. The studies reported here were designed to meet this objective.

The hydrology for the basin during the study period is presented and discussed in terms of the historic setting and the frequency with which these conditions occurred under historic conditions. These flows are then related to geomorphological conditions and changes in the river in an analysis of river channel dynamics. The river channel dynamics studies include analysis of river cross-sections, response of cobble bars, movement of bed material and an analysis of suspended sediment data.

Water temperature data collected at nine stations along the San Juan and Animas Rivers are reported and compared to historical data to aid the assessment of habitat quality.

The results of the geomorphic reach definition study completed in 1994 are reported here. The results of this study are used as a basis for analysis of the several data sets, with the objective of identifying similarities and differences in the response of these reaches to flows.

Physical habitat mapping that has been completed on the San Juan River from Navajo Dam (river mile (RM 224) to the confluence with Lake Powell (RM 0) from 1992 through 1997 is reported here (1998 data reduction is not complete).

Habitat quality studies were also conducted between 1994 and 1996 to identify the temporal and longitudinal distribution of physical and biological components of habitat quality in riffles, runs and backwaters.

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SAN JUAN RIVER STUDY AREA DESCRIPTION

The San Juan River is a major tributary of the Colorado River and drains 99,200 km^2 in Colorado, Utah, Arizona, and New Mexico (Figure 1.1). From its origins in the San Juan Mountains of southwestern Colorado at elevations exceeding 4,250 m, the river flows westward for about 570 km to the Colorado River. The major perennial tributaries to the San Juan River are the Navajo, Piedra, Los Pinos, Animas, La Plata, and Mancos rivers, and McElmo Creek. In addition there are numerous ephemeral arroyos and washes contributing little total flow but large sediment loads.

Navajo Reservoir, completed in 1963, impounds the San Juan River, isolating the upper 124 km of river and partially regulating downstream flows. The completion of Glenn Canyon Dam and subsequent filling of Lake Powell in the early 1980's inundated the lower 87 km of the river, leaving about 359 km of river between the two bounding features.

From Navajo Dam to Lake Powell, the mean gradient of the San Juan River is 1.67 m/km. Locally, the gradient can be as high as 3.5 m/km, but taken in 30 km increments, the range is from 1.24 to 2.41 m/km. Between the confluence of the San Juan River with Lake Powell and the confluence with Chinle Creek about 20 km downstream of Bluff, UT, the river is canyon bound and restricted to a singled channel. Upstream of Chinle Creek the river is multi-channeled to varying degrees with the highest density of secondary channels between the Hogback Diversion about 13 km east of Shiprock and Bluff, Utah. The reach of river between Navajo Dam and Farmington, NM is relatively stable with predominantly embedded cobble substrate and few secondary channels. Below the confluence with the Animas River, the channel is less stable and more subject to floods from the unregulated Animas River. Between Farmington and Shiprock cobble substrate still dominates, although it is less embedded. Between Shiprock and Bluff the cobble substrate becomes mixed with sand to an increasing degree with distance downstream, resulting in decreasing channel stability.

Except in canyon-bound reaches, the river is bordered by nonnative salt cedar (*Tamanix chinensis*) and Russian olive (*Elaeagnus angustifolia*) and native cottonwood (*Populas fremonti*) and willow (*Salix* sp.). Nonnative woody plants are most abundant with cottonwood and willow accounting for less than 15% of the riparian vegetation.

Discharge of the San Juan River is typical of rivers in the American Southwest. The characteristic annual pattern is one of large flows during spring snowmelt, followed by low summer, autumn, and winter base flows. Base flows are frequently punctuated by convective storm-induced flow spikes during summer and early autumn. Prior to closure of Navajo Dam about 73% of the total annual discharge (based on USGS Bluff, Utah gage) of the drainage occurred during spring runoff (1 March through 31 July). The median daily peak discharge during spring runoff was 10,400 cfs (range = 3,810 to 33,800 cfs). Although flows resulting from summer and autumn storms contributed a comparatively small volume to total annual discharge in the basin, the magnitude of storm-induced flows exceeded the peak snowmelt discharge about 30% of the years, occasionally exceeding 40,000 cfs (mean daily discharge). Both magnitude and frequency of these storm induced flow spikes are greater than those seen in the Green or Colorado rivers.

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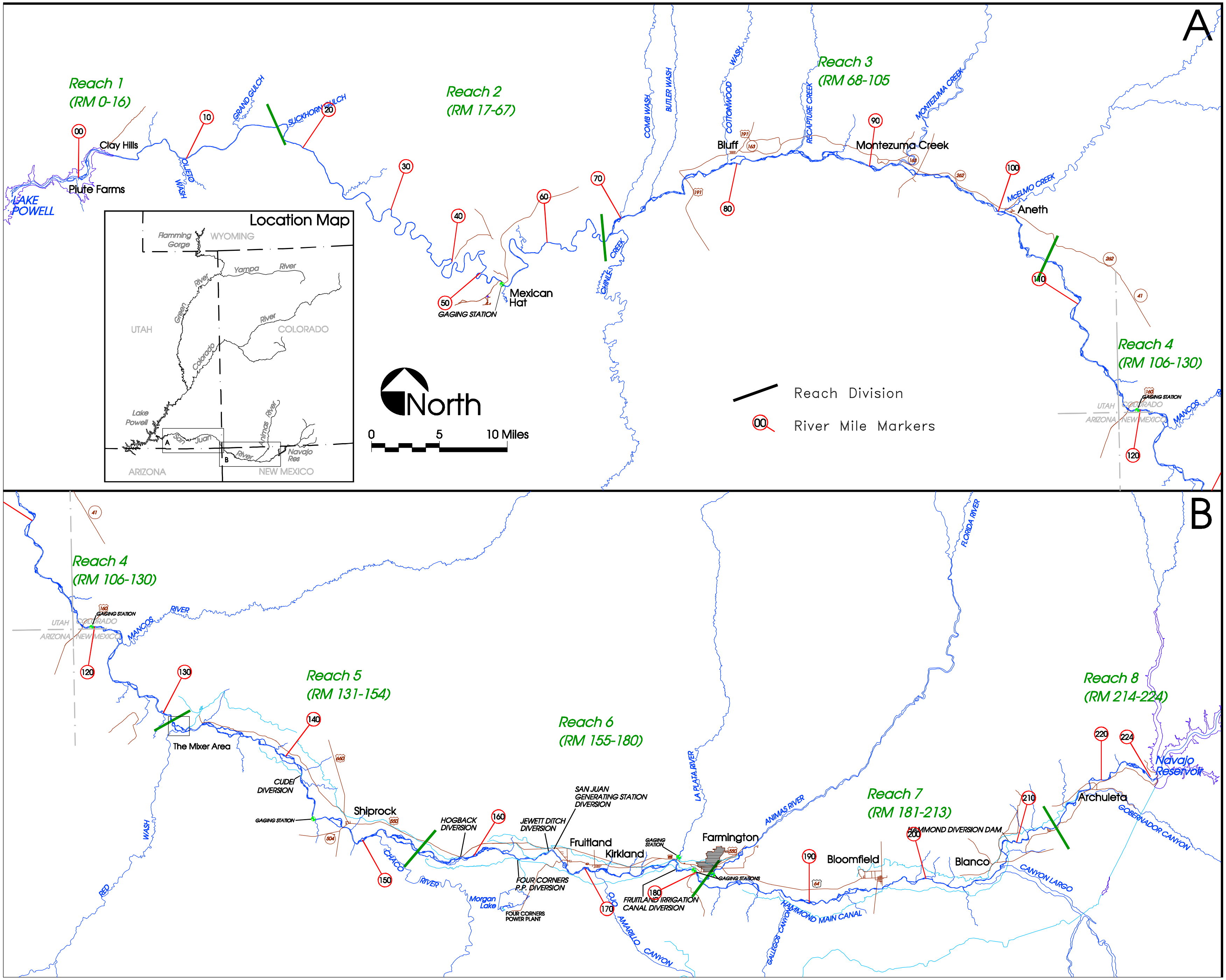

Figure 1.1. **San Juan Basin Location Map**

Closure of Navajo Dam altered the annual discharge pattern of the San Juan River. The natural flows of the Animas River ameliorated some aspects of regulated discharge by augmenting spring discharge. Regulation resulted in reduced magnitude and increased duration spring runoff in wet years and seriously reduced magnitude and duration spring flows during dry years. Overall, flow regulation by operation of Navajo Dam has resulted in post-dam peak spring discharge averaging about 54% of pre-dam values. After dam closure, base flows were increased substantially over pre-dam base flows.

Since 1992, Navajo Dam has been operated to mimic a "natural" hydrograph with the volume of release during spring linked to the amount of precipitation during the preceding winter. Thus in years with high spring snowmelt, reservoir releases were "large" and "small" in low runoff years. Base flows since 1992 were typically greater than during pre-dam years but less than post-dam years.

The primary study area for most studies conducted under the auspices of the San Juan River Seven Year Research Program, including that reported herein, were accomplished in the mainstem San Juan River and its immediate vicinity between Navajo Dam and Lake Powell. Between Navajo Dam and Shiprock there is considerable human activity within the floodplain of the San Juan River. Irrigated agriculture is practiced throughout this portion of the valley and much of the immediate uplands. Much of the river valley not devoted to agriculture (crop production and grazing) consists of small communities (e.g. Blanco and Kirtland) and several larger towns (e.g. Bloomfield and Farmington). The valley of the Animas River, the San Juan's largest tributary in the study area, is similarly developed. Downstream of Shiprock to Bluff small portions of the river valley (and uplands) are farmed; dispersed livestock grazing is the primary land use. In the vicinity of Montezuma Creek and Aneth, petroleum extraction occurs within the floodplain and the adjacent uplands. Between Bluff and the confluence with Lake Powell, there are few human-caused modifications of the system.

To enhance comparisons among studies and to provide a common reference for all research, a multivariate analysis of a variety of geomorphic features of the drainage was performed to segregate the river into distinct geomorphic reaches. This effort (See Chapter 3 for details) identified eight reaches between Navajo Dam and Lake Powell. The reach locations are shown on Figure 1.1. The following provides a brief characterization of each reach. The details behind the reach definitions appear in Chapter 3.

Reach 1 (RM 0 to 16, Lake Powell confluence to near Slickhorn Canyon) has been heavily influenced by the fluctuating reservoir levels of Lake Powell and its backwater effect. Fine sediment (sand and silt) has been deposited to a depth of about 12 m in the lowest end of the reach since the reservoir first filled in 1980. This deposition of suspended sediment into the delta-like environment of the river/reservoir transition has created the lowest-gradient reach in the river. This reach is canyon bound with an active sand bottom. Although there is an abundance of low velocity habitat at certain flows, it is highly ephemeral, being influenced by both river flow and the elevation of Lake Powell.

Reach 2 (RM 17 to 67, near Slickhorn Canyon to confluence with Chinle Creek) is also canyon bound but is located above the influence of Lake Powell. The gradient in this reach is higher than in either adjacent reach and the fourth highest in the system. The channel is primarily bedrock confined and is influenced by debris fans at ephemeral tributary mouths. Riffle-type habitat dominates, and the major rapids in the San Juan River occur in this reach. Backwater abundance is low in this reach, occurring most in association with the debris fans

Reach 3 (RM 68 to 105, Chinle Creek to Aneth, Utah) is characterized by higher sinuosity and lower gradient (second lowest) than the other reaches, a broad floodplain, multiple channels, high island count, and high percentage of sand substrate. This reach has the second highest density of backwater habitats after spring peak flows, but is extremely vulnerable to change during summer and autum storm events, after which this reach may have the second lowest density of backwaters. The active channel leaves debris piles deposited throughout following spring runoff, leading to the nickname “Debris Field”.

Reach 4 (RM 107 to 130, Aneth, Utah, to below “the Mixer”) is a transitional reach between the upper cobble-dominated reaches and the lower sand-dominated reaches. Sinuosity is moderate compared with other reaches, as is gradient. Island area is higher than in Reach 3 but lower than in Reach 5, and the valley is narrower than in either adjacent reach. Backwater habitat abundance is low overall in this reach (third lowest among reaches) and there is little clean cobble.

Reach 5 (RM 131 to 154, the Mixer to just below Hogback Diversion) is predominantly multi-channeled with the largest total wetted area (TWA) and largest secondary channel area of any of the reaches. Secondary channels tend to be longer and more stable than in Reach 3 but fewer in number overall. Riparian vegetation is more dense in this reach than in lower reaches but less dense than in upper reaches. Cobble and gravel are more common in channel banks than sand, and clean cobble areas are more abundant than in lower reaches. This is the lowermost reach containing a diversion dam (Cudei). Backwaters and spawning bars in this reach are much less subject to perturbation during summer and fall storm events than the lower reaches.

Reach 6 (RM 155 to 180, below Hogback Diversion to confluence with the Animas River) is predominately a single channel, with 50% fewer secondary channels than Reaches 3, 4, or 5. Cobble and gravel substrates dominate, and cobble bars with clean interstitial space are more abundant in this reach than in any other. There are four diversion dams that may impede fish passage in this reach. Backwater habitat abundance is low in this reach, with only Reach 2 having less. The channel has been altered by dike construction in several area to control lateral channel movement and over-bank flow.

Reach 7 (RM 181 to 213, Animas River confluence to between Blanco and Archuleta, New Mexico) is similar to Reach 6 in terms of channel morphology. The river channel is very stable, consisting primarily of embedded cobble substrate as a result of controlled releases from Navajo Dam. In addition, much of the river bank has been stabilized and/or diked to control lateral movement of the channel and over-bank flow. Water temperature is influenced by the hypolimnetic release from Navajo Dam and is colder during the summer and warmer in the winter than the river below the Animas confluence.

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Reach 8 (RM 213 to 224, between Blanco and Archuleta and Navajo Dam) is the most directly influenced by Navajo Dam, which is situated at its uppermost end (RM 224). This reach is predominantly a single channel, with only four to eight secondary channels, depending on the flow. Cobble is the dominant substrate type, and because lateral channel movement is less confined in this reach, some loose, clean cobble sources are available from channel banks. In the upper end of the reach, just below Navajo Dam, the channel has been heavily modified by excavation of material used in dam construction In addition, the upper 10 km of this reach above Gubernador Canyon are essentially sediment free, resulting in the clearest water of any reach. Because of Navajo Dam, this area experiences much colder summer and warmer winter temperatures. These cool, clear water conditions have allowed development of an intensively managed blue-ribbon trout fishery to the exclusion of the native species in the uppermost portion of the reach.

The studies in this report concentrate on the 359 km of river described as the SJRIP study area. However, the various studies reported here have narrower or broader focus, depending on the nature of the study. Geomorphic characterization studies have been completed for the main San Juan River from Navajo Dam to Lake Powell. Historical analyses have been completed for the San Juan Basin, including some tributaries, although the comparative historic aerial photos are primarily from the main stem of the river. This analysis extends from Navajo Dam to the original confluence with the Colorado River. Habitat mapping extent varies depending on the mapping run, with the most extensive mapping completed from Navajo Dam (RM 224) to the confluence with Lake Powell (RM 0). The Animas River from the Colorado state line to the confluence with the San Juan was also mapped in 1993 for baseline analysis. Habitat Quality studies were completed from Navajo Dam to the confluence with Lake Powell.

HISTORICAL SETTING

Little information on the nature of the San Juan River before man's intervention exists. Bryan (1925) reported an observation from 1849 describing the Chaco River, a tributary to the San Juan, as being 2.4 meters wide and 0.5 meters deep. However, by 1925, Bryan found that the river was 46 to 137 meters wide and 7 to 9 meters deep. This description is consistent with other reports that indicate the start of significant arroyo incision occurring between 1883 and 1890 for the Colorado Plateau (Graf 1987; Mundorff, 1982, Gellis, etal 1991). This rapid erosion of the watershed contributed large quantities of sediment to the San Juan River. Pierce (1917) and Miser (1924) indicated that the sediment load was so high during summer storm runoff that it had the "appearance of a stream of molen red metal, instead of its usual rough, choppy surface". Miser reported seeing fish floating on the surface during such events and locals reported fish kills associated with storm events. Miser attributed these mass loadings to a major change in the valley bottoms of adjacent tributaries which are now heavily eroded. He suggested the main cause to be a combination of overgrazing and climate change.

Unfortunately, no photographs of the river prior to 1883 could be found. An early set of aerial photography taken in 1935 by the Soil Conservation Service shows a broad, sandy channel bottom with little or no vegetation and an extensively braided stream for much of the river below Shiprock,

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NM. With the large sediment loading that came as a result of water shed erosion prior to 1935, this condition is likely not representative of the natural channel.

In the early 1940's the sediment load to the San Juan River changed with a reduction in sediment inflow and outflow (Tompson, 1982). Theories for the change include climate change (Leopold, 1976), invasion of tamarisk (Graf, 1978) or the natural evolution of land forms (Gellis et al., 1991). These conditions have worked together to provide a reduction in sediment load and stabilization of the flood plain to allow establishment of vegetation and subsequent channelization of the river.

Since the condition of the river prior to the large sediment loading is unknown, no reliable model exists to describe the requirements to restore habitat to conditions that existed before man's intervention. Even if the nature of the channel prior to man's intervention was known, it is unlikely that changes in the operation of Navajo Dam could restore those conditions. Two many changes have occurred, including large deposits of sand and invasion of non-native vegetation, to allow restoration.

Since restoration of truly natural system is not possible, another approach must be taken. The conditions desirable for the target fish species must be identified based on present use in the San Juan River and other rivers in the Colorado River drainage, the response of those habitats to flow changes and habitat modification determined, and modifications to flow and habitat made to improve conditions for the native fish community. The studies reported here were designed to accomplish this.